

and Ocean Basins," in which, after giving the views of Herschell and Airy, I bring out this idea very prominently, and illustrate it by many diagrams. An abstract of this paper, by Sterry Hunt, was published in the *Canadian Naturalist*, vol. iv., 1859, p. 293, and reference to it will be found in the "Royal Society Catalogue," vol. iii. p. 919.

A very brief outline of the paper is as follows:—I make two assumptions: (1) an internal liquid with floating crust; (2) the crust of continental areas more conductive and therefore cooling and thickening more rapidly than that of oceanic areas.

It is evident that under these assumptions inequalities would commence first on the under surface of the crust by additions there, making convexities beneath the continental and concavities beneath the oceanic areas. But by flotation these inequalities on the under side next the liquid would be reproduced on the upper side next the atmosphere, and by this means alone continents would grow continually higher, and ocean beds deeper. Now add to these erosion. By cutting down continents and filling up the seas erosion would tend constantly to destroy these inequalities, while flotation would tend as constantly to reproduce them. Thus according to this view the continents rise partly by additions beneath and partly by removal above, and similarly the ocean beds sink partly by increased concavity beneath and partly by additions above. But evidently if unequal thickening should stop, flotation could only *partly* restore the inequalities destroyed by erosion.

Except the abstract above referred to, the paper was never published, and in February, 1865, it was destroyed, along with much else, by Sherman's army. My reason for not publishing more fully was that I soon became dissatisfied with it; for about that time the views of Hopkins and Pratt on the solidity of the earth began to attract attention, and I became convinced that dynamical geology must be reconstructed on a basis of a solid earth. But now that the idea of a sub-crust liquid or semi-liquid layer is becoming prominent (a condition which would not probably interfere with the substantial solidity of the earth in its astronomical relations), it seemed to me important that this long forgotten paper should be brought forward merely as a part of the history of the subject.

Now a few words on the subject of the communications referred to in the beginning of this letter. It seems to me that some of your correspondents have gone too far in regarding unloading by erosion as a cause of elevation. Evidently there must be some other and more fundamental cause, or erosion could not act. Evidently erosion can only partly restore an elevation produced by some other cause. Erosion is primarily an effect of elevation, only in this as in so many other cases the effect may react as a cause, to maintain the elevation. For example, the Colorado plateau region has been raised since Cretaceous times about 20,000 feet, but the maximum general erosion has been only about 12,000 feet. The erosion has been, therefore, the consequence, not the cause, of elevation, for it is impossible that the cause should lie so far behind the effect. I give this one example because it is on so large a scale, but every mountain range furnishes an example of great erosion as an effect of elevation produced by other causes. That loading and unloading the crust is a cause of subsidence and elevation there is little doubt, but that there are other and far more important causes is certain.

Berkeley, Cal., December 3

JOSEPH LECONTE

#### Red-deer Horns

IN continuation of my remarks on the eating of shed deer-horns by other deer, I have to add that six shed horns in various stages of erosion have been sent to me from Sutherlandshire. They each bear well defined teeth-marks on the gnawed portions, and this leaves little if any doubt that the popular belief that the horns are eaten by deer is founded on fact. The accompanying interesting letter from Mr. James Inglis, which gives the evidence of two experienced stalkers, both most intelligent and reliable men, is further confirmation of a curious though no doubt very natural habit of the deer, which finds in the lime-salts of the horn a necessary element of nutrition. You will observe that Inglis believes the deer use the molars in eating the bone, and this seems probable enough, as they apparently always begin at the points and eat towards the beam and burr, a method of proceeding by which they can bring portions of the horn within the action of the molars.

December 27, 1883

J. FAYRER

"... I send a few red deer horns that have been partially gnawed by deer in the forest. I asked the stalkers to keep a look out and see if they could find any deer eating horns, and am glad to say that they have been able to put the matter beyond all doubt.

"Donald McRae saw with his glass a stag, in Dunrobin Glen, eating a horn; he went to the place where he saw him eating it, and found it partially eaten. I send it with the others. You will find a tick on it to distinguish it from the rest.

"Duncan McPherson saw with his glass a hind, last week, eating a horn also; he did not find the horn, but he saw her (the hind), quite plainly, with it in her mouth, gnawing away at it near the point.

"Deer have no incisors in the upper jaw, but they have grinders or molars in both upper and lower jaws, formidable enough to eat any horn, and I have no doubt that it is with their molars that the horns are eaten.

"A shepherd in the parish of Lairg has a cow that eats all the bones she can find, and goes miles for them, and eats them up, shank bones and all; ribs are eaten easily, and seem to give no trouble whatever.

"JAMES INGLIS

"December 24, 1883"

#### On the Absence of Earthworms from the Prairies of the Canadian North-West

NOT by any means the least remarkable of the very notable series of works which Mr. Darwin has given to the world is that which came last from his pen but a short time previous to his lamented death. Dealing, as it does, with effects which, when looked at in the detail, are exceedingly small and insignificant, but, when viewed in the aggregate, are shown to be of surprising importance, the "Vegetable Mould and Earthworms" must certainly rank as a most strikingly interesting work.

It is not my desire to call in question the conclusions at which Mr. Darwin has arrived with regard to the action of earthworms in cultivating the soil, but I wish to point out that in one extensive portion of the earth's surface, to which much attention has of late been directed on account of its agricultural capabilities, earthworms do not exist. I refer to the vast region commonly known as Manitoba and North-West Territories. My friend, Mr. E. E. T. Seton, of Carberry, Manitoba, was the first to point out to me that this enormous country must be regarded as forming an exception to Mr. Darwin's generalisations, on account of the total absence from it of every kind of earthworm, and, having lately returned from a visit to these regions, I can add my testimony to his in this particular, as well as in the matter of the amazing, innate fertility of the soil, which has been the wonder and remark of all travellers for years past, but which, in this case, obviously cannot be attributed to the action of worms, since these do not exist there. In addition to my own observations, I have the testimony of numbers of intelligent settlers, most of whom had been several years in the country, but all of whom unhesitatingly assured me that such a thing as an earthworm was unknown. Further, Mr. Leo Rogers, son of Mr. Thos. Rogers of Manchester, who has spent several years with the engineers of the Canadian Pacific Railway, has informed me that earthworms are unknown between Winnipeg and the Rockies. This being the case, it does not seem reasonable to suppose that they exist anywhere in the huge territory still further to the north, and comprising upwards of 3,000,000 square miles of land, or something like one third of the entire North American continent, and which may therefore be regarded as forming an exception to Mr. Darwin's statement (p. 120), that "Worms are found in all parts of the world, and some of the genera have an enormous range. They inhabit the most isolated islands; they abound in Iceland, and are known to exist in the West Indies, St. Helena, Madagascar, New Caledonia, and Tahiti. In the Antarctic regions worms from Kerguelen Land have been described by Ray Lankester, and I have found them in the Falkland Islands. How they reach such isolated spots is at present quite unknown." In connection with the statement (p. 121) that "Worms throw up plenty of castings in the United States," it may be pointed out that the boundary line (the 49th parallel) is to some extent a natural one, from which the rivers run both north and south. Further, I have been assured by friends, and have also seen with my own eyes, that earthworms abound at Toronto and in other parts of Ontario. This being the case, an interesting inquiry arises as to the cause of the absence of worms from the North-West, and I can only suggest two probable reasons—the great cold of winter and the

prevalence of prairie fires in spring and autumn. Personally I favour the latter, though both causes may in part be answerable. If worms abound in Iceland ( $65^{\circ}$  N. lat.), in Kerguelen Land ( $50^{\circ}$  S. lat.), and in Toronto ( $43^{\circ}4'$  N. lat., mean winter temperature  $27\frac{1}{4}^{\circ}$  F.), why should they not also occur at Winnipeg ( $50^{\circ}$  N. lat.)? Certainly the mean winter temperature is very low, being about  $8^{\circ}$  F., and the mean minimum for eleven years —  $40\frac{3}{4}^{\circ}$  F. I made special inquiries as to the depth to which the soil in Manitoba becomes frozen in winter. This is often as much as five or six feet, but only, I believe, in the more exposed places, and certainly as a rule it is thawed again in the spring. I do not think this would render the ground uninhabitable by worms when they are able to exist in Iceland. Mr. Darwin says nothing as to the effect of frost on worms except (p. 26) that "worms are sensitive to a low temperature, as may be inferred from their not coming out of their burrows during a frost"; but he states (p. 110) that they are easily able to descend three or four or even seven or eight feet below the surface. It would be interesting to ascertain whether worms inhabit equally cold portions of the Old World.

But the agency which I believe has caused the absence of earthworms from the North-West is, as already stated, the prairie fires which annually sweep over enormous portions of the country, totally consuming the grass, and converting it into a black ash. This, it might well be imagined, would for months together completely deprive any worms that formerly existed of that variety of decaying vegetable matter that composes their food; and assuming that fires have annually passed over large portions of the prairies for scores of generations (as seems in every way probable), it appears to me only reasonable to suppose that this cause would effectually have exterminated the worms from the country or have prevented them occupying it. It is my belief (as I shall elsewhere state more fully) that the very fertile, fine, black, powdery, and almost soot-like soil from one to three feet thick, even the open, treeless nature of the prairies themselves, and the absence from their surface, so far as my observation goes, of every single species of mollusk, while many species abound in all the ponds, lakes, and streams, are all in a large degree, if not entirely, due to the action of the fire. If this view ultimately turns out to be correct, it will be further seen that the very means which has deprived the soil of the North-West of that natural cultivation which the soils of most other countries enjoy has, at the same time, liberally supplied it with a manure resulting from the charred ashes of the grass which is annually burned. My friend, Mr. T. Rogers, who has taken much interest in the absence of worms from the North-West, and is inclined to attribute it rather to frost than to fire, though he suggests that the "alkali" may possibly have had something to do with it, has already brought the subject before the Literary and Scientific Society of Manchester, where he seems to have met with a good deal of incredulity.

As another evidence of the absence of worms, the numerous, large, Glacial boulders that strew the prairies around Brandon and elsewhere may be cited. These, had worms existed, would doubtless have long ago been lowered beneath the surface, as also the skulls and other bones of buffaloes, which so abound on the prairies, and most of which have evidently lain there a long while. Nevertheless some of these have been buried in the course of time, as one gentleman told me that he had sometimes turned them up from a depth of two or three inches beneath the surface when ploughing. Their burial may have been accomplished by the wind drifting soil over them, or by the working of gophers. Of these peculiar little animals two species are very abundant on the prairies, where they make extensive burrows, which it seems possible may to some extent accomplish the natural cultivation of the soil in the way worms are accustomed to do it elsewhere. Some more suggestive remarks on this point may be found in a paper by Mr. Seton, published in the Report of the Manitoba Department of Agriculture for 1882, and which may be studied with advantage. ROBT. MILLER CHRISTY

Chignal St. James, near Chelmsford, December 20, 1883

#### Magnetic Dip in South China and Formosa

WHILE engaged on a meteorological mission in China I availed myself of the opportunity to make the following determinations of the magnetic dip. The observations in Hong Kong were made at the public gardens, the Observatory being not yet

ready. On October 10 I observed at the British Consulate; on November 3 at the English Presbyterian Missions Compound, Swatow. In Amoy I observed at the residence of the Commissioner I.M. Customs, in Takow (Formosa) at the Custom House, and at the South Cape (Formosa), near the magnificent fortified lighthouse. It is to be feared that the observations on the coast of China are slightly vitiated from local attraction, the rocks consisting of ferruginous granite. Southern Formosa is built up of coral, raised in places to a great height, no doubt through volcanic action. Slight earthquakes are of common occurrence in Formosa, whereas along the coast of China they are rare and of no importance except to the seismologist.

Place	Date	Local M.T. h. m.	Dip.
Hong Kong ...	1883, Nov. 5 ...	5 9 p.m. ...	32 17
" ... "	" 9 ...	5 4 " ...	32 19
Swatow ...	" Oct. 10 ...	5 24 " ...	34 23
" ... "	" Nov. 3 ...	11 25 a.m. ...	34 17
Amoy ...	" Oct. 14 ...	3 50 p.m. ...	36 45
" ... "	" 16 ...	5 10 " ...	36 50
Takow ...	" 24 ...	2 45 " ...	32 54
South Cape ...	" 27 ...	4 0 " ...	31 24
" ... "	" 28 ...	4 30 " ...	31 27.5
" ... "	" 29 ...	3 20 " ...	31 24.5

W. DOBERCK,  
Government Astronomer

#### THE ORIGIN OF CORAL REEFS

REGARDING this interesting geological problem, which has recently been discussed in NATURE, we are enabled through the kindness of Mr. Murray, of the Challenger Commission, to publish a letter which has been addressed to him by Dr. Guppy from the Pacific. The importance of this communication will be recognised in the confirmation it supplies of the inference that coral reefs start upon a platform of limestone composed of the remains of foraminifera, &c., and are themselves of no great thickness. Dr. Guppy will no doubt continue his researches, and we may hope to obtain from him precise data regarding the average thickness of the coral rock, the lithological difference between it and the underlying limestone, the structure of the limestone, whether any succession of organisms can be detected in it, and whether at any point the underlying volcanic rock can be seen which would afford a measurement of the thickness of the calcareous deposits. The effects of denudation and their relation to height above the sea will no doubt also receive his attention.

"Shortlands Islands, Solomon Group,  
August 7, 1883

"During the twelve months I have spent in this group of islands—serving as surgeon on board H.M. surveying-ship *Lark*—I have been much interested in and have devoted considerable attention to the raised coral formations in various islands; and as my observations may be of service towards confirming the views which you have advanced with reference to coral islands and reefs, I will state briefly the results of my observations.

"Excluding the large continental islands, I will refer for the sake of brevity to the numerous small islands of this archipelago, those of volcanic, and those of calcareous formations. Confining myself to the islands of calcareous formation, I will pass over the numerous small islands which are entirely composed of coral detritus, sand, and shells, and have been formed by the materials thrown up by the waves at the present sea-level; and will restrict my remarks to a very common type of islands in this group, with gently sloping and rounded profile, having an elevation varying perhaps between 100 and 1100 or 1200 feet, and composed in bulk of an *impure earthy or argillaceous limestone*, usually bedded, and almost always *foraminiferous*, now and then rich in other pelagic organisms, such as *Pteropods*. On this rock rests the